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Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

THE EFFECT OF WELD IMPERFECTION ON THE RELIABILITY OF ERW PIPES PROGRESS REPORT: PHASE 1.

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ENGINEERING PHYSICS SECTION

APRIL, 1987

8 pp

PHYSICAL METALLURGY RESEARCH LABORATORIES

REPORT: PMRL 87-24(TR)

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by

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ABSTRACT

The study of weld imperfection in ERW pipes is a joint project between CANMET and the pipe manufacturers and users. Most of the ERW pipes containing artificial weld imperfections were supplied by Stelco. Tensile specimens and full-size pipe specimens have been prepared for testing. The sizing of weld flaws by radiographic and ultrasonic methods is progressing well. An acoustic emission unit with pattern recognition software has been received. It will be used to locate flaws and monitor the deformation and fracture. No cracking was observed in tests of ERW pipe coupons with and without weld flaws carried out in H_2S saturated sea water. Future work plans are described

LABORATOIRES DE RECHERCHE EN METALLURGIE PHYSIQUE

RAPPORT: PMRL 87-24(TR)

ÉTUDE DES IMPERFECTIONS DE SOUDAGE VERSUS LA FIABILITÉ DES PIPELINES SOUDÉS PAR RÉSISTANCE ÉLECTRIQUE. RAPPORT DE PROGRESSION: PHASE 1

par

K.C WANG, G. LANDRY et G.R. HOEY

RÉSUMÉ

L'étude de défauts de soudage dans les tuyaux soudés par résistance électrique est un project conjoint entre Canmet, les manufacturiers et les utilisateurs de tuyau. Stelco a fourni la plupart des échantillons comportant des défauts artificiels. Les coupons d'essais de traction ayant la configuration recommendée par AGA et des spécimens de pipeline ont été préparés. Le dimensionnement de défauts de soudure par radiographie et ultrason progresse bien. Un appareil d'émission acoustique avec reconnaissance de formes a été reçu et sera utilisé pour localiser les défauts et surveiller la déformation et la rupture. La fissuration par Hydrogène sulfureux d'échantillons de pipeline soudés par résistance électrique avec ou sans défauts dans le cordon de soudure n'a pas montré de différence en ce qui concerne la fissuration et aucune fissuration ne fut observée. Les plans de travail futures sont exposés.

INTRODUCTION

The study of the effect of weld imperfections on the reliability of ERW pipes was initiated by the late Dr. M. Godden in 1985. A meeting was called in Calgary in February 1985 and a work plan approved (see Appendix). In 1985 Dave Muir of Stelco shipped several batches of ERW pipe cutouts with weld imperfections for NDT sizing experiments. In February 1986 Stelco shipped 21 sections, three metres in length, of Grade 414 (MPa), 324 mm diameter ERW pipes with controlled artificial-penetrator type weld imperfections. Of these, twelve lengths had a wall thickness of 12.24 mm. Not all the intended imperfections were detected by mill ultrasonic inspection. The other 9 lengths had a wall thickness of 14.27 mm but in these samples, all intended imperfections were detected. Subsequently, Ipsco and Prudential sent pipe rejects from production runs. The O.D.'s of these pipes were 114 mm and 168.3 mm respectively.

MECHANICAL PROPERTIES

The mechanical properties in the weld region of ERW welded pipes were evaluated by Battelle Columbus Division (BCD) under an AGA contract(1,2). Normally, pipe plate tensile specimens with a weld located transversely across the center of the gauge section will fail outside the weld region in a tensile test. A tensile specimen with notches in the welded region, shown in Fig. 1, was proposed by BCD to evaluate the mechanical properties of an ERW weld. This configuration forces the specimen to fail in the weld and should be useful in evaluating the effect of weld imperfections.

Eighteen welded tensile specimens of this configuration containing artificial weld imperfections and 6 specimens with sound welds have been prepared. Tensile specimens of the same configuration with notches in the pipe body and conventional pipe tensile specimens were also prepared to study the effect of notching.

A 3 m long, 324 mm O.D. pipe specimen with artificial penetrator-type weld defects has been prepared. This pipe specimen is being used for non-destructive sizing of weld imperfections and for setting up an acoustic emission unit for flaw locating and pattern recognition. The pipe has been pressurized to 6.8 MPa and active flaws identified.

All specimens have not yet been tested because some imperfections still have to be sized.

NONDESTRUCTIVE SIZING OF IMPERFECTIONS AND ACOUTIC EMISSION TESTING

In 1985 J. Newbury sized the flaws by ultrasound and K. Meleskie by radiography. Since mid-1986 Gilles Landry has performed all NDT evaluation including the acoustic emission monitoring of imperfections during pressure testing.

Radiographic sizing—Three methods were tried for sizing flaws by radiography. The densitometer method is not very reliable as many variables can affect the exposed film intensity and the flaw depth is difficult to estimate. Analysis of a vertical view and an angle view of a flaw gives a better estimate of flaw depth. Currently, a vertical view is used to locate the flaw and then a double exposure parallel method is used to locate and size the flaws in the thickness direction. This last method seems to give the best estimate but for tight cracks it is difficult to use.

Ultrasonic sizing— Sizing flaws by ultrasonics is the ultimate objective because the double exposure radiographic method is not suitable for sizing flaws in ERW pipe welds during manufacture. Various methods were tried to size the flaws, first on EDM machined pipe coupons, then on tensile specimens with welds located transversely in the middle. The conventional amplitude of the reflected beam technique, time of flight and focused transducer with water jacket methods have all been tried for sizing flaws. Software has also been written to calculate Axicon lens angle.

Acoustic emission—An acoustic emission unit with signal analyzing software was developed under contract by Tektrend in Montreal. This unit has four transducers for flaw location. The software "Icepack-Intelligent Classifier Engineering Package", can be trained to recognize signals from plastic deformation, crack initiation, crack propagation, weld imperfections during welding, etc. In a preliminary test, signals were received when the ERW pipe specimen with artificial imperfections was pressurized to 6.8 MPa.

CORROSION TESTING

Dr. G. Hoey is the scientist responsible for this project. The cracking susceptibility of welds of ERW pipes was investigated by a modified NACE Standard TM-02-84 test. Longitudinal weld coupons parallel to the pipe rolling direction with and without imperfections (100 mm x20 mm x 14.27 mm WT) were exposed to H_2S saturated sea water solutions for 4 days (final pH=5.0). Diffusible hydrogen was determined at the end of the test followed by examination of the coupons for cracking by ultrasonic C-scan. Cracking was not observed (Table 1). The diffusible hydrogen values also indicate high resistance to cracking.

FUTURE WORK PLAN

Mechanical properties—From a radiographic examination of the tensile specimens, the weld imperfections were not located exactly where punch marks indicated. Nevertheless, tensile specimens were made with the punch mark aligned with the specimen axis. However, most of the imperfections were not found in the middle of the specimen. A new set of tensile specimens will be prepared with the flaws located in the center of the specimen.

On the inside surface welds are improperly trimmed. This will be studied further.

The sizing of flaws is progressing rapidly and tensile specimens will be tested soon. However, pipe specimens cannot be tested until sizing is complete.

Nondestructive testing—The planned activities are listed as follows:

1. Use tip corner timing and diffraction methods to size flaws in the calibration block first, then size flaws in tensile specimens to confirm the results from radiographic method.
2. Use the same method on pipe sections of known flaw size to determine curvature effects.
3. Size flaws in ERW pipe welds.
4. Use the acoustic emission unit to locate the most active flaw and use the Icepak software to monitor crack initiation and propagation from it.

Corrosion testing—Future work will include an investigation of SSC resistance of ERW weld samples with and without weld flaws.

REFERENCES

1. M.E. Mayfield and W.A. Maxey, ERW weld zone characteristics, AGA NG-18 Report No.130, AGA catalog L51488, 1982.
2. D.N. Williams, A method for evaluation the ductility of the seam weld in the ERW pipe, AGA NG-18 Report No.141, AGA Catalog L51427, 1984.

Table 1. Results of hydrogen sulfide induced cracking tests of ERW weld samples

Coupon No.	Weld Flaws	Cracking	Diffusible H_2 mL(STP)/100 g steel
2H1B	yes	no	1.0
2H2B	yes	no	1.4
2H3B	yes	no	1.5
2H4G	no	no	1.6
2H5G	no	no	2.0
2H6G	no	no	1.3
2I1B	yes	no	0.7
2I2B	yes	no	1.4
2I13B	yes	no	1.4

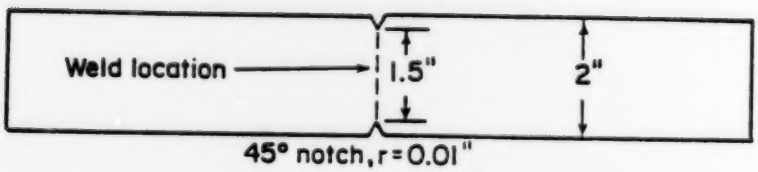

Fig. 1. Notched tensile specimen to evaluate ERW pipe welds